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Attaining and Maintaining Self-sufficiency in Wheat Production: Institutional Efforts and Farmers' Limitations

UMAR FAROOQ and MUHAMMAD IQBAL

1. INTRODUCTION

Becoming an economically prosperous state is the ultimate goal of all economic policies of Pakistan. Being an agricultural country, this calls for more realistic measures towards increasing agricultural production and exports with a simultaneous decrease in imports. The agricultural sector of Pakistan has the primary responsibility of producing enough food for its ever-growing population. Wheat, being the staple food, is the most important crop from food-security perspectives. It is also the largest grain crop in terms of acreage, constituting about 75 percent of total food grain production and is grown under almost every crop rotation. Pakistan imports wheat quite regularly because its domestic production has remained short of demand. Pakistan's present requirement of wheat is more than 20 million tonnes,[1] of which, 18.05 million tonnes was produced within the country during 1998-99 and the rest was imported [Pakistan (1999)]. By the year 2020, annual wheat imports alone are projected to be 15 million tonnes costing US$ 2 billion (at 1990 dollar exchange rate) per annum [PARC (1996)].[2] Thank God, during rabi 1999-2000, national wheat production exceeded domestic demand.[3] In future, whether Pakistan shall be able to

Umar Farooq and Muhammad Iqbal are respectively Scientific Officer at Agricultural Economics Research Unit of PARC at AARI, Faisalabad, and Deputy Director, Social Sciences Division, PARC, Islamabad.

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[1]MINFAL has estimated the domestic wheat requirements for 2000-01 as 21.321 million tonnes [MINFAL (2000)].

[2]By the year 2020, the population of Pakistan would be between 245-260 millions and the national wheat requirements might be between 38-42 million metric tonnes annually [Rajaram *et al.* (1998)].

[3]In the irrigated Punjab, major contributing factors were: (i) about 4 percent expansion in area under wheat; (ii) increase in area planted in time (i.e. till 30th November) due various reasons in different zones; (iii) increase in the support prices of wheat with no increase in fertiliser prices; and (iv) favourable weather

sustain this status or the gap between domestic production and national requirements will widen? This will remain a frequently raised question at various forums. Rajaram *et al.* (1998) are of the view that it is doubtful whether wheat production under the current low growth scenario can meet the projected demands. This situation demand attention from all wheat concerned quarters ranging from policy-makers and wheat researchers to the common wheat growers in Pakistan.

The present paper is aimed at reviewing past institutional efforts made in relation to wheat and the achievements made. Attention is also focused on the personal and farm attributes of an average farmer, his perceptions and constraints in the application of modern wheat production techniques. The underlying objective is to compare and highlight the differences between research recommendations and farmers' limitations? Suggestions are also offered for various institutions to achieve and sustain self-sufficiency in wheat production.

This paper is organised as follows. Section 2 summarises past wheat production achievements and its present status. Section 3 reviews the research efforts from biological and social scientists and the future challenges ahead. It particularly reviews the findings related to agricultural economic and policy analyses. Section 4 discusses the farm level limitations in obtaining higher wheat yields. Section 5 is devoted to the suggested reforms for various institutions to accomplish and sustain self-sufficiency in wheat production in the long run.

2. WHEAT PRODUCTION: PAST ACHIEVEMENTS AND PRESENT STATUS

Before Green Revolution, average annual growth in wheat production was 1.3 percent, which rose to an impressive rate of 4.17 percent during the Green Revolution period (1967-68 to 1986-87). However, in the Post-Green Revolution era (after 1987-88), this pace could not be maintained and has fallen to 2.86 percent.[4] On the other hand, the area under wheat was estimated to be increasing by 1.53, 1.43 and 0.94 percents per annum during Pre-Green, Green and Post-Green Revolution periods, respectively. Given a high and unchanged population growth, decline in the growth rates of area, yield and production during the Post-Green revolution has further widened the gap between domestic wheat requirements and the production.

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prevailed throughout the season [Farooq and Bashir (2000)].

[4]This breakdown of Post-Green Revolution period was made after reviewing various studies [e.g. Byerlee (1987); Hamid *et al.* (1987)] indicating that Green Revolution phase was completed by 1986-87 because by this time more than 90 percent of total wheat area was under HYVs, every farmer was applying fertiliser to wheat crop and developments in irrigation has intensified crop production.

This led to a sharp increase in average wheat imports by 257 percent compared with the Green Revolution (Table 1).

Table 1

Average Growth Rates of Area, Production, Yield, and Quantity of Wheat Imported in during Pre-, Post-, and Green Revolution Periods

Period	Area (%)	Production (%)	Yield (%)	Qty. Imported (000 T)
Pre-Green Revolution 1947-48 to 1966-67	1.53	1.30	0.23	821.8
Green Revolution 1967-68 to 1986-87	1.43	4.17	2.718	41.2
Post-Green Revolution 1987-88 to 1998-99	0.94	2.86	1.90	2159.6

Sources: Agricultural Statistics of Pakistan, various issues.
SSD, 1989, "Statistical Bulletin on Wheat in Pakistan".

During 1999-2000, wheat was planted at 8.44 million hectares, 6.18 million hectares in Punjab and the remaining in other provinces. This implies that Punjab is the major wheat producing province of Pakistan. In Pakistan, more than 85 percent of total wheat area is sown in irrigated belts and the remaining is planted in *barani* areas. In Punjab and Sindh provinces, more than 88 and 96 percent of wheat area was sown on irrigated lands respectively whereas in NWFP, the ratio of irrigated and *barani* plantations was 40:60. In Balochistan, because of drought, all the wheat area was planted on irrigated lands during *rabi* 1999-2000 whereas more than 85 percent wheat area was planted under this environment during previous year [MINFAL (2000a)]. In irrigated belts, wheat is mainly planted after cotton, rice, sugarcane and maize whereas in *barani* tracts, it is planted after sorghum, millet, maize and groundnut.

3. BIOLOGICAL AND SOCIAL SCIENCES RESEARCH IN WHEAT CROP: SALIENT FINDINGS

The wheat production achievements so far made in Pakistan are mainly attributed to the research efforts from plant breeders in developing varieties highly input responsive and resistant to diseases. Over the past three decades, more than 60 wheat varieties have been released, out of which only 25 varieties were commercially adopted.[5] This adoption level is insufficient and resulted in mono-varietal culture on

[5]The number of varieties released since 1965 (release year of Maxipak) are more than eighty rather than sixty. Most of the wheat varieties released are listed in Annexure-1.

farmers' fields. Still more can be achieved through successful diffusion of certified seed of good varieties [Rajaram *et al*. (1998)].[6] On the other hand, it is difficult to find good examples of crop management research that have been widely adopted and diffused among farmers.[7] Recommendations about input application are fairly general and usually lack cropping systems perspectives. Commodity based research tends to ignore interactions between different crops and various agronomic issues. At present, there is also a shortage of research and operational funds needed for proper equipment leading to a decline in the effectiveness of research [Faruqee and Carey (1995)].

Although in the past, economic returns to wheat research in Pakistan have been sufficiently high, the lower estimates computed by Byerlee (1990, 1993) signifies a major challenge for researchers and policy-makers (Table 2). The relatively higher estimates computed by Nagy (1991) and Azam *et al.* (1991) may be because the periods considered by them were fairly long and also contain some part of Pre-Green Revolution period. Moreover, during the periods considered by them, at water-seed-fertiliser technological package of the Green Revolution was highly subsidised and also backed by heavy investments in irrigation projects and research collaboration with CIMMYT, Mexico.[8] On the other hand, the period considered by Byerlee (1990, 1993) was fairly short, covering second half of Green Revolution and withdrawal of subsidy on improved seed and fertiliser was already practiced[9] thus making these complementary inputs relatively expensive resulting in low growth in their application. The persistent shortage of funds for research and lack of proper institutional support for successful diffusion of modern production practices may be other underlying reasons for low returns to research.

Chaudhry and Sahibzada (1995) indicated some detrimental effects of the removal of subsidy on agricultural inputs such as seed, fertiliser and pesticides in order to lessen the increased burden on national budget and creating competition in the major input markets through privatisation, deregulation and de-nationalisation.

Table 2

Estimated Rates of Returns to Investment in Wheat Research in Pakistan

[6]Presently, nearly one-fourth total wheat seed requirement is distributed as certified seed.

[7]For instance, the zero tillage and direct seeding techniques were developed for timely wheat plantation but these methods were not popularised among farmers despite the inventors' claim that these techniques are highly profitable.

[8]For instance, the annual growth rate of major crops was highest during 1964-65 to 1969-70 i.e. 9.14 percent per annum [Malik *et al.* (1994)].

[9]Gradual withdrawal of subsidies on agricultural inputs was started during early 1980s.

Author and Year	Period Considered	Estimated Rate of Return
Nagy (1991)	1964-1981	About 60 percent
Azam *et al.* (1991)	1956-1985	76 percent
Byerlee (1993) (only Punjab)	1978-1987	16-25 percent

They were of the view that such policy actions may lead to inefficiency of input use because the use of modern inputs is already much below the recommended levels and price increases will further depress the intensified use of modern inputs. As small sized farms dominate Pakistan's agriculture, an uncontrolled increase in the prices of inputs is also harmful for these farmers which may lead to income distribution and rural poverty problems as spillover effects.

The yield gap between research stations and the farmers' fields indicates the extent of maximum benefits that can be realised by managing the crop in a better way or like scientists do at research stations. In irrigated Punjab, best wheat yield trials on research stations have produced 6.6 t/ha. This yield declined to 5.3 t/ha using recommended levels of inputs. Applying farmers' input levels, the maximum possible yield obtained was 3.8 t/ha whereas the average farmer was obtaining only 2 t/ha. This implies a considerable yield potential that can be realised. They have also estimated wheat yield gaps under various environments of Punjab and NWFP provinces. It was found that there exists a wheat yield gap of 26 percent in irrigated NWFP whereas in Punjab, it was 37 percent under rice-wheat rotation, 31 percent under cotton-wheat rotation and 41 percent in rainfed areas. Major factors responsible for these gaps are the varieties planted, late sowing, poor weed control, seed quality, deep tillage and drill planting [Hussain *et al*. (1990)].

Byerlee and Siddique (1990) first detected wheat yield sustainability problem in Pakistan's Punjab. They concluded that long-term stagnation in wheat yields per hectare has arisen due to the factors such as: (1) increased cropping intensity causing delay in wheat plantation; (2) increased weeds and disease problem; (3) use of poor quality tubewell water; and (4) low efficiency of fertiliser used. Many of these factors are not well understood or quantified. The emphasis should be shifted from raising wheat yields through higher inputs' use to increasing yields by more efficient input management. A well coordinated and in-depth investigation into the sustainability issues of wheat yield was suggested. Such research should be conducted by involving specialists from major disciplines in order to find a comprehensive solution of the problem.

Heisey *et al.* (1993) found that yield gains may continue to be the most important factor affecting varietal change during Post-Green Revolution period, but not as spectacular as in the Green Revolution era. The results of a farm level survey showed that the factors causing slow varietal change in Pakistan are disease vulnerability, farm-to-farm transfer of information and low literacy levels. Farmers'

opinions about general and yield specific characters were also important in the varietal adoption. Agricultural Extension was found having little impact on awareness and adoption. Strengthening formal educational and extension systems may be crucial elements of continued agricultural productivity growth in Post-Green Revolution agriculture.

Analyses of wheat supply in relation to change in output price reveals that irrespective of the type of data used (primary or secondary) and methodology employed, the short-run wheat supply elasticities found estimated between 0.1 and 0.5 whereas the long-run elasticities ranges from 0.2 to 0.99 (Table 3). The highly inelastic supply of wheat suggest that in order to increase wheat supply, institutional support such as research, extension, development of irrigation facilities, a more efficient inputs provision system are also needed along with price incentives.

An overtime comparison between cost of production and support prices shows that the support prices of wheat are equal to the costs at farm gate.[10] The ratio of support prices to the import prices of wheat paid by Pakistan shows that, on average, 72.25 percent of import prices were offered as support price (Tables 4 and 5). Therefore, in the scenario of support prices covering production costs (with zero profit margins), the extension efforts for inducing the farmers to use higher quantities of modern inputs are seriously endangered. This may be another cause of depressed use of inputs to wheat production and hindering expansion in the area under wheat. An intuitive question also arises that when there is no profit margin in wheat production, why farmers did not stop growing wheat and shift to other profitable crops? The reason for continued wheat planting may be due to: first, wheat is a necessary food crop primarily meant for domestic consumption and used in various payments made in kind to artisans and hired labour. Secondly, many imputed costs such as land rent, interest on capital, management cost, expenses saved by employing family labour for operations like weeding, irrigation, harvesting and threshing, may not be duly considered by wheat growers [Farooq (1997)]. Therefore, farmers may evaluate profit as money above cash costs of purchased inputs. Farooq (1997) estimated that cash costs constitute about 65 percent of the total cost of wheat production in the rice zone of irrigated Punjab.

From the above discussion, it is clear that although wheat breeders performed excellently, however, the process of varietal replacement at farmers' fields remained slow. There was also a non-significant transfer and diffusion of crop management research to farmers' fields. On the other hand, the returns to research in wheat are

[10]This comparison is at mean level, very general and does not consider variations in the cost of production between producers of various types. Moreover, setting prices below average costs does not necessarily mean that a significant proportion of producers will not make a profit. It has dynamic aspect too, such as the potential for reducing costs through adoption of more modern technologies.

low, wheat supply elasticities are smaller in magnitude and the rates of growth in area and yield are also low. Moreover, the price policy[11] measures are not very conducive for higher inputs use or making investment in wheat production. All these imply a need for making various improvements in different institutions.

Table 3

Short- and Long-run Elasticity Estimates of Wheat in Pakistan

Reference	Period of Estimation	Short-run Elasticity	Long-run Elasticity
Cumings (1975)	1949-68	0.10	0.22
Askari and Cumings (1977)	1950-68	0.07	0.21
Gotsch and Gilbert (1980)	1934-65	0.06	0.31
	1960-76	0.07	0.35
Bale and Lutz (1981)	–	0.17	0.53
Tyers (1984)	1960-80	0.10	0.15
Seeley (1985)	1961-76	0.10	0.51
Tweeten (1987)	1960-83	0.14	0.40
Ali (1988)	1957-86	0.23	0.33
Ashiq (1992)	1975-76 to Punjab:	0.45	0.94
	1987-88 Sindh:	0.47	0.99
Farooq (1997)*	1994-95	0.16	–
Ashfaq *et al.* (2000)	1971-96	0.092	0.20

Source: Ashiq (1992), p. 95.

*Farm survey data from rice-wheat zone of Punjab, Pakistan.

Table 4

Differences between Prices Proposed by Cost of Production Committee and Prices Set by the Government

(Rs/40 Kg)

Years	Cost at Farm Gate	Proposed Support Price	Price Fixed by Government	Support Price as % of Cost of Production	Support Price as % of Proposed Price	Margin Suggested by APCOM
1981-82	67.97	69.97	58.00	85.33	82.89	2.9
1982-83	65.27	73.99	64.00	98.05	86.50	13.4
1983-84	72.59	81.99	64.00	88.17	78.06	12.9
1984-85	75.87	84.56	70.00	92.26	82.78	11.5
1985-86	75.38	86.22	80.00	106.13	92.79	14.4
1986-87	78.86	90.05	80.00	101.45	88.84	14.2
1987-88	80.22	91.54	80.00	99.73	87.39	14.1
1988-89	83.46	95.11	85.00	101.85	89.37	14.0
1989-90	99.15	112.37	96.00	96.82	85.43	13.3
1990-91	119.73	131.86	112.00	93.54	84.94	10.1
1991-92	109.40	120.00	124.00	113.35	103.33	9.7

[11]The lower wheat/flour prices also carries the danger of smuggling of the commodity across borders as well as the limited and uncertain supply to the domestic consumers collectively increasing their miseries.

1992-93	122.79	138.00	130.00	105.87	94.20	12.4
1993-94	143.80	150.00	160.00	112.27	106.67	4.3
1994-95	152.59	180.00	160.00	104.86	88.89	18.0
1995-96	166.50	185.00	173.00	103.90	93.51	11.1
1996-97	190.03	205.00	185.00	97.35	90.24	7.5
Average				**100.00**	**89.74**	**11.5**

Source: From 1981-82 to 1990-91, Government of Punjab 1991, p. 50; From 1991-92 to 1996-97, APCOM, Pakistan.

Table 5

Domestic Procurement Prices Relative to World Prices for Wheat

Years	Quantity of Wheat Imported (M.T.)	Price Paid (Rs/M.T.)	Price Paid ($/ton)	Wheat Supp. Price (Rs/ 40 Kg)	Exchange Rate (Rs/$)	Support Price in ($/ton)	Ratio of S. Price to Imp. Price (%)
1980-81	305	2076	209.49	58.00	9.91	146.32	69.85
1981-82	360	2224	224.42	58.00	9.91	146.32	65.20
1982-83	396	2204	173.41	64.00	12.71	125.89	72.60
1983-84	291	2952	218.99	64.00	13.48	118.69	54.20
1984-85	980	2807	185.28	70.00	15.15	115.51	62.34
1985-86	1909	2472	153.16	80.00	16.14	123.92	80.91
1986-87	378	3132	182.31	80.00	17.18	116.41	63.86
1987-88	601	3079	174.94	82.50	17.60	117.19	66.99
1988-89	2171	3229	168.00	85.00	19.22	110.56	65.81
1989-90	2047	4197	195.66	96.00	21.45	111.89	57.18
1990-91	972	3208	143.09	112.00	22.42	124.89	87.28
1991-92	2018	4205	169.28	124.00	24.84	124.80	73.72
1992-93	2868	4212	162.25	130.00	25.96	125.19	77.16
1993-94	1902	3804	126.13	160.00	30.16	132.63	105.15
1994-95	2617	4874	157.99	160.00	30.85	129.66	82.07
1995-96	1968	7718	229.91	173.00	33.57	128.84	56.04
1996-97	2500	7570	194.10	240.00	39.00	153.85	79.26
1997-98	4088	7413	171.60	240.00	43.20	138.89	80.94
Average							**72.25**

Source: Calculations made using various issues of *Economic Survey*.

Before reaching any final conclusion and offering some recommendations, it seems appropriate to consider the attributes of our farming community and the problems faced by an average wheat grower. The following section is devoted to these considerations.

4. FARM LEVEL CONSTRAINTS TO HIGHER WHEAT PRODUCTIVITY

Turning to farm level constraints to wheat production, many farm and farmer

specific problems of both endogenous and exogenous nature are discussed in the following sections.

Resource Quality

Farm Operators' Characteristics

The farm level surveys in Pakistan show that farming business is mainly operated by farmers who are more than 40 years old, having more than 20 years of farming experience and more or less primary school education. Although farming experience of our farmers is quite long yet low level of education is creating problems of various nature. For instance, because of limited understanding about crop production on scientific lines, they are unable to calculate the desired nutrient level (or N-P-K Ratio) according to the fertility status and with different fertiliser combinations. They have limited knowledge about diagnosing various diseases, type of insects/pests attacks and their economic threshold levels. They have limited knowledge about various malpractices encountered during input procurement and output marketing (e.g. weighing). In other words, they are "*learning by doing*" rather than "*doing by learning*". The weedicide/pesticide dealers are more or less matriculate and are profit-oriented people. They give little consideration to farmers' problems and try to sell the products available at their shop. Sometimes farmers have to procure inputs on credit basis, therefore, they have to purchase what is available with the dealer. Only medium and large farmers are able to obtain good quality pesticides/weedicides as they are in a position to negotiate better business deals with the dealers or companies. The dealers also provide on-line technical help to big landlords.

Quality of Wheat Seed and On-farm Seed Management

Seed is a strategic input that can significantly enhance or constrain production. The basic genetic capability transmitted through seed allows more efficient use of various inputs and cultural practices. PARC (1987) estimated that more than one million ton of wheat production losses are attributed to the use of diseased seed and mixture of varieties. Bashir (1993) reported that not a single farmer in the sample of 150 farmers applied certified seed. Seed from the previous wheat crop is the single most important source in wheat production. In irrigated Punjab, about 49 percent farmers in rice zone and 40 percent farmers in cotton zone have managed their wheat seed separate from the wheat kept for home consumption [Tetlay *et al.* (1987)]. Under increased cropping intensity scenario, application of own seed always led to sowing of a variety at wrong time. In other words, there are cases when a farmer having seed of an early variety is sowing it either late or at medium time and vice

versa. This also caused negative effects on wheat yields.

Ground Water Quality

Siddique (1994) has made some remarks about the quality of subsoil water of the Indus basin as: First, majority of the ground waters are of marginal quality and most of these waters are only suitable for restricted irrigation. Hence, these waters must be carefully managed with regular application of certain amendments like gypsum; Second, ground water quality is often good in aquifers close to large canals or near the head of distributaries. The canal system is the most important source of aquifer recharge in the Indus basin. This implies that application of tubewell water may be one of the reasons deteriorating wheat yields.

Institutional Limitations

Narrow Genetic Diversity

The wheat varietal surveys of mid-eighties conducted by the provincial Agricultural Economics Research Units (AERUs) of Pakistan Agricultural Research Council (PARC) indicate that farmers allocated about half of total wheat area to only one variety which has now risen to more than 70 percent (Table 6). Long run persistence of mono-varietal cultures usually increase probably of disease epidemics,

Table 6

Percent Area under Dominant Wheat Varieties in Pakistan

Author(s) and Year	Province	Production Zone	% Area	Major Varieties
Khushk *et al.* (1987)[1]	Sindh	Cotton Zone	50.8	Pavon
	Sindh	Sugarcane Zone	54.3	Pavon
Khushk *et al.* (1987)[2]	Sindh	Cotton Zone	54.6	Pavon
	Sindh	Sugarcane Zone	63.0	Pavon
	Sindh			
Khushk *et al.* (1990)		Cotton Zone	34.0	Pavon
			20.0	Yekora
Farooq *et al.* (1993)	Punjab	Cotton Zone, 1985-86	37.2	WL-711
			21.2	Sonalika
	Punjab	Cotton Zone, 1988-89	35.6	Sonalika
			17.4	PAK-81
	Punjab	Cotton Zone, 1991-92	58.8	PAK-81
AERU, Faisalabad (1998)	Punjab	Cotton Zone, 1997-98	77.9	Inqalab-91
Farooq *et al.* (1993)	Punjab	Rice Zone, 1985-86	26.3	PAK-81
			17.4	Punjab-81

	Punjab	Rice Zone, 1988-89	54.8	PAK-81
	Punjab	Rice Zone, 1991-92	85.4	PAK-81
AERU, Faisalabad (1998)	Punjab	Rice Zone, 1997-98	75.9	Inqalab-91
Farooq *et al*. (1993)	Punjab	Mixed Zone, 1985-86	n.a.	
	Punjab	Mixed Zone, 1988-89	24.4	PAK-81
			13.0	WL-711
	Punjab	Mixed Zone, 1991-92	62.4	PAK-81
AERU, Faisalabad (1998)	Punjab	Mixed Zone, 1997-98	69.8	Inqalab-91

[1] Farmers' perceptions. [2] Breeders' perceptions. n.a. = Not Available.

thus putting national food security at greater risk. From farmers' perspectives, this is because: (1) the performance of an already adopted variety is not very poor as compared with the new candidate/competing varieties; (2) the certified seed of improved varieties is not easily available. Many institutions related factors are also responsible for it. These are: (1) non availability of wheat varieties having significant edge for yield and disease resistance; (2) limited quantity of certified seed available; (3) high prices of certified seed; (4) relatively less number of seed distributing companies involved in wheat seed business; and (5) problems in timely distribution of the seed of appropriate varieties as wheat is grown in all provinces of Pakistan.

Inputs Availability and Their Quality

Because wheat is mostly planted in rotation with crops like cotton, rice and sugarcane, therefore, the turn around time between harvesting of these crops and wheat plantation is quite narrow. This lead to a substantial demand for fertilisers, seed and other inputs that need to be fulfilled within a short span of time. Hence prevalence of shortages or black marketing in inputs markets along with quality related problems was a regular phenomenon in the recent past [e.g Sharif *et al.* (1994)]. All these collectively cause deteriorating impacts on wheat productivity.

Technological Limitations

Line Sowing of Wheat

The Department of Agriculture Punjab recommends line sowing preferably by drill, but majority of farmers sow it by broadcast method. A recent field experiment conducted in the rice zone Punjab revealed that wheat sown by drill yielded 7.2 percent higher as compared with the broadcasted fields [Majid and Gill (1999)]. Such a small difference in yields at experiment stations may be one of the reasons of not practising drill sowing of wheat at farm level. A recent field survey of AERU, Faisalabad in the mixed cropping zone of Punjab revealed that time shortage and non-availability of wheat drills are the major reasons of opting for broadcast method.

The other reasons include non-removal of the stubbles of previous kharif crops, highly pulverised seedbed needed, missings in germination due to drill closure (Table 7).

Low Fertiliser Doses

Fertiliser is one of the key inputs that play an important role in augmenting the productivity. The soils of Pakistan are deficient in three major nutrients, i.e. nitrogen, phosphorous and potassium (N-P-K). Almost all soils lack nitrogen. The Department of Agricultural Extension Punjab recommends fertiliser for three types of soils, i.e.

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poor, medium and highly fertile soils (the base of their classification is not clear). The N-P-K doses recommended for the year 1998-99 were 128-114-62=304 nutrient kilograms/ha on poor soils, 104-84-62=250 nutrient kilograms/ha for medium soils and for fertile soils 79-57-62=198 nutrient kilograms/ha [Department of Agriculture (1998)]. On the other hand, farmer field surveys indicate that farmers are applying much less than the recommended dose with a wide variation in the N-P-K ratios across farmers of various categories. Some of the institutions related factors are also responsible for this (Table 7).

Weed Control

Incidence of weeds is becoming a serious problem to higher wheat production in all wheat growing areas of Pakistan. Continuous practising of crop rotations like rice-wheat and cotton-wheat is partly attributed to such incidence [Rajaram *et al.* (1998)]. *Phalaris minor* and wild oat are serious problems in the rice and cotton zones of Punjab respectively [Ahmad *et al.* (1988)]. It is estimated that 10 percent increase in wheat production can be achieved by controlling weeds [Rajaram *et al.* (1998)]. Byerlee *et al.* (1984) estimated that weeds could cause a yield loss as high as 500 kg/ha whereas Byerlee and Siddique (1990) concluded that in Punjab, about 50 kg/ha loss in wheat yield is attributed to weeds infestation. From the farmers' perspectives, higher weedicide prices, adulteration and delay in weedicide application due to various reasons, brackish underground water, shortage of canal water and the wait for one's turn for canal water are major problems to effective weed control (Table 7).

Irrigation/Moisture Management at Critical Stages

Water is the key input for efficient utilisation of plant nutrients, consequently better crop growth and yield per hectare. Scheduling of irrigation is a key to the water management. In case of wheat, biological scientists consider three important stages at which non-application of irrigation cause significant decline in wheat yields. These are crown root stage which arrives 20-25 days after sowing, the flowering stage called boot or *gobh* stage arriving at 85-90 days after sowing, and milky stage prevailing after 112-117 days from the sowing date. The farmers having access to tubewells are in a relatively better position to manage timely irrigation provided the ground water is fit for irrigation. From farmers' perspectives, the problems faced in timely irrigation management include canal closure for de-silting or no rains, farm location at tail end of watercoursel, higher prices of tubewell water and brackish underground water (Table 7).

Spillover Limitations

Late Planting of Wheat

The time of sowing is an important factor in wheat production. The Department of Agricultural Extension, Punjab considers first two weeks of November as the optimum time of wheat sowing. It maintains that wheat planted after 20th November could cause a yield loss @ 1 percent per day means, an average yield loss of 35-50 kg/ha/day. The survey data of different studies show that in the cotton zone of Punjab, 94 percent of wheat was sown in time[12] during 1970 but this had fallen to only 30 percent during 1985 and further to 23.4 percent during 1998. In the rice zone Punjab, 40 percent wheat was planted on time in 1984 and 22 percent during 1998. The obvious cause of late sowing under cotton-wheat rotation, is that cotton fields remained occupied till late December for an extra picking. In rice-wheat rotation, late maturity of basmati paddy (basmati-370) was the main constraint till mid-1980s, which was solved to some extent after the release of Basmati-385 variety of rice.

5. PROPOSED INSITUTIONAL SUGGESTIONS FOR ACHIEVING HIGHER PRODUCTION CHALLENGES

In the present 'Post-Green Revolution' age, agriculture has become more science based rather than merely adoption based. In other words, for achieving due benefits of a technology, besides having its thorough understanding (i.e. quantity of inputs to be used, their application time and application method), due institutional support is also equally essential. On one hand, this calls for creating more awareness among farmers about various wheat production techniques. On the other hand, besides price incentives, comprehensive efforts from various institutions such as research, extension, technology transferring and inputs supplying agencies and mass media are also required. Some guidelines for their individual working areas are briefly delineated below:

Agricultural Research and Extension

The agricultural research institutions are suggested to concentrate more on the following:

- *"It is an axiom of experience in plant breeding that if you stop, you regress. The natural enemies of the wheat crop are themselves active and evolutionary. Rusts and other pathogens mutate, insects develop resistance to*

[12]i.e. up to November 30.

chemical control, ….". [CIMMYT (1989), p. 112]. Institutions related to wheat breeding are suggested to evolve varieties having significant yield edge over already adopted/existing ones, equally suitable for sowing at early, medium and late seasons, highly input responsive, disease and drought resistant rather than merely concentrating on number of varieties released. PAK-81 and Inqalab-91 are such example. Breeders of major kharif crops rotating with wheat are suggested to evolve more early maturing varieties so that timely plantation of wheat is ensured.

- There should be an exchange of empirical findings (experiments and farmers' fields based) among wheat breeders, breeders of kharif crops (like cotton, rice and sugarcane) and agricultural economists on various aspects such as additional benefits (e.g. yields of kharif crops due to late vacation of fields for wheat) and costs involved (e.g. wheat yield loss due to late sowing, other carrying effects of previous crops) in other to finetune research recommendations for various zones.
- Most of the crop management trials (like impacts of sowing dates, fertiliser doses, pesticide use, irrigation management and varietal trials) contain large gap between treatments/sub-treatments and zero application is used as the control. It is suggested that crop management research must be conducted in the farming systems perspectives. In other words, the control should not be zero application of the factor considered, it must be representative of farmers' practice like average/minimum application level of an input or the input level applied by majority of the farmers. The gaps between treatments should be small enough to guide the farmers more precisely about the impacts of little changes in their inputs use patterns.
- The higher official in research such as directors are suggested to approve the research proposals addressing ordinary farmer production constraints in various micro-environments with experimental designs containing above mentioned aspects.
- More detailed empirical work is suggested for various types of trade-offs in conflicting technologies like zero tillage, direct seeding and raised bed planting etc.

Agricultural Economics and Policy Analysis

The agricultural economic and policy analyses are mostly conducted in the neo-classical perspective. Various allied factors related to input use and implementation of various policies are usually ignored. For instance, some aspects about wheat productivity analysis are suggested to consider during data collection and analysis.

- Appropriateness of the input applied, e.g. type of chemical used for weeds/ disease control.
- Quality of inputs used and their application time, e.g. quality of seedbed prepared, quality of seed, quality of underground water applied, application/non-application of critical inputs at various critical stages of crop growth.
- Incorportion of systems perspective, crop rotation and environmental factors.
- Types of competing enterprises and marketing facilities available in the area.

Agricultural Extension and Mass Media

The agricultural extension and mass media are important sources of keeping farmers informed about various developments in agricultural research and policy decisions. Moreover, agricultural extension also assumes an important role in transferring/demonstrating the improved crop production techniques. For wheat, these institutions are proposed to consider the following.

- Launching special campaigns for advisory services related to wheat crop management (e.g. choice of varieties, selection of weedicides and their application methods etc.) for the farmers during wheat production season.
- Convincing/educating farmers for crop management decisions such as importance of certified seed in sustaining wheat yields, plantation of at least two varieties, allocation of more area to new HYVs, importance of timely sowing of wheat and application of higher doses of fertiliser with at recommended N-P-K ratios.
- Mass media are suggested to keep updating the farmers' knowledge about improved wheat production practices and time to time decisions to be taken by the farmers. The practice of delivering some tips before major news bulletins should be continued on radio and television.

Agricultural Marketing Institutions

For the agricultural marketing related institutions, we have following suggestions.

- Guaranteed sufficient supply of good quality inputs at their application times and at fair prices or the prices fixed by the government.
- Strict control over malpractices of all kinds, e.g. adulteration, black-marketing, selling of expired products etc.
- Introduction of certified seed in small sized packings.

Agricultural Policy-makers

The agricultural policy-makers are requested to award due consideration to the followings:

- Low returns to wheat research do not necessarily imply that it is futile to invest in wheat research. This may be partly because of persistent shortage of funds for research. Recognising that more realistically designed research can make some breakthrough, it is suggested that substantial increase in the funds for agricultural research including wheat may be granted.
- Appropriate incentives may be provided to the farmers for promoting the use of deep tillage implements, zero tillage drills, increased application of phosphatic fertiliser, certified seed, weedicides. In view of shortage of canal water available, the electricity for tubewells may also be subsidised.
- The support price of wheat should be production encouraging in order to induce higher application of various expensive and critical inputs such as phosphatic fertilisers, weedicides and tubewell water.
- Encouraging private sector in the wheat seed business through appropriate incentives.
- Business pertaining to plant protection inputs should be licenced to qualified technical persons with refresher courses.

Agricultural Credit Institutions

Agricultural credit institutions occupy significant position in farming business. Despite exploiting our farmers in various ways, informal sources of credit play significant role in our farming communities. Formal credit institutions are proposed to consider the followings.

- Special credit facilities should be offered to small farmers of all tenancy categories under one window operation.
- Special loaning facilities should be offered for installing tubewells in the areas where underground water is suitable for irrigation.
- Credit may also be provided to the people interested in establishing farm machinery pools.

Irrigation Institutions

Irrigation related institutions are suggested to:

- Continue the de-silting of canals for improving water availability to farmers at the tail end.
- Appropriate measures for reducing water losses due to seepage and leakages etc.
- Proper maintenance of SCARP tubewells.

In conclusion, although most of the proposed suggestions are fairly general and equally applicable to other crops also. No single institutional effort can be claimed as sufficient for achieving the higher wheat production targets. Above all the blessings from Almighty God is also required like rabi 1999-00.

Although the discussion of the present paper is mainly based on the situation in the Punjab province, it is hoped that this focus does not seriously distort the general arguments advanced, the derived conclusions and proposed institutional suggestions.

ANNEXURE

Annexure 1

List of Wheat Varieties Released in Pakistan Since 1965

Variety Name	Province	Release Year	Variety Name	Province	Release Year
Maxipak-65	Punjab	1965	Faisalabad-85	Punjab	1985
Tarnab-69	NWFP	1969	Tandojam-83	Sindh	1985
Khushal-69	NWFP	1969	Niab-183	Sindh	1985
Barani-70	Punjab	1970	Pirsabak-85	NWFP	1986
Chenab-70	Punjab	1970	Sutlej-86	Punjab	1986
Nuri-70	Punjab	1970	Sarsabz	Sindh	1986
Blue Silver	Punjab	1971	Chakwal-86	Punjab	1988
SA-42	Punjab	1971	Khyber-87	NWFP	1988
Lyallpur-73	Punjab	1973	Chakwal-86	Punjab	1988
Pari-73	Punjab	1973	Rawal-87	Punjab	1988
Sandal-73	Punjab	1973	Punjnad-88	Punjab	1988
Tarnab-73	NWFP	1973	Shalimar-88	Punjab	1988
Pothwar	Punjab	1973	Pasina-90	NWFP	1990
Pak-70	Punjab	1974	Barani-91	Punjab	1991
Yecora-70	Punjab	1975	Soghat-90	Sindh	1991
Nuri-70	Punjab	1975	Mehran-89	Sindh	1991
SA-75	Punjab	1975	Inqlab-91	Punjab	1991
ARZ	Islamabad	1976	Rohtas-90	Punjab	1991
Punjab-76	Punjab	1976	Pasban-90	Punjab	1991
LU-26	Punjab	1977	Anmol	Sindh	1993
WL-711	Punjab/Sindh	1978	Rohtas-90	Punjab	1991
Sonalika	Punjab	1978	Pirsabak-91	NWFP	1992
ZA-77	Sindh	1979	Bakhtawar-93	NWFP	1993
Zargoon-79	Balochistan	1979	Zardana-89	Balochistan	1993
Jauhar-78	Sindh	1979	Sariab-92	Balochistan	1993
Tarnab-79	NWFP	1979	Kaghan-93	NWFP	1993
Indus-79	Punjab	1979	Bahawalpur-94	Punjab	1994
B. Pur-79	Punjab	1980	Pothowar-93	Punjab	1994
Khyber-79	NWFP	1980	Parwaz-94	Punjab	1994
Pavon	Punjab	1980	Drawar-96	Punjab	1995
Zamindar-80	Balochistan	1980	Kohsar-95	Punjab	1996
Punjab-81	Punjab	1981	Punjab-96	Punjab	1996
Pak-81	NWFP/Pb	1981	Shahkar-95	Punjab	1996
Sindh-81	Sindh	1982	Abadgar-93	Sindh	1996
Barani-83	Punjab	1983	AZRI-96	Balochistan	1996
Sarhad-82	NWFP	1983	Kiran-95	Sindh	1996
TJ-83	Sindh	1984	Nowshera-96	NWFP	1996
Faisalabad-83	Punjab	1984	Suleman-96	NWFP	1996
Sindh-83	Sindh	1984	Tatara	NWFP	1996
Kohinoor-83	Punjab	1984	MH-97	Punjab	1997

Wadanak-85	Punjab	1985	Iqbal-99	Punjab	2000
Punjab-85	Punjab	1985	Auqab-99	Punjab	2000

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